ADVANCES IN FORESTRY SCIENCE

OPEN ACCESS

Mimosa caesalpiniifolia Benth. as an alternative for wood production in Northeast Brazil

Paulo Mauricio Medeiros Reis[1] Juliana Lorensi do Canto[1] João Gilberto Meza Ucella Filho[2] Débora de Melo Almeida[3] Bruna Rafaella Ferreira da Silva[3] Alex Nascimento de Sousa[3] Gualter Guenther Costa da Silva[1]*

[1]Universidade Federal do Rio Grande do Norte, Unidade Acadêmica Especializada em Ciências Agrárias, Macaíba - RN, Brasil
[2]Universidade Federal do Espírito Santo, Departamento de Ciências Florestais e da Madeira, Jerônimo Monteiro - ES, Brasil
[3]Universidade Federal Rural de Pernambuco, Departamento de Ciência Florestal, Recife - PE, Brasil

Original Article

***Corresponding author:**
debooraalmeida@gmail.com

Keywords:
Semiarid

Caatinga

Forestry

Reforestation

Palavras-chave:
Semiárido

Caatinga

Silvicultura

Reflorestamento

Received in
2022/06/16

Accepted on
2023/05/11

Published in
2023/06/30

DOI:
http://dx.doi.org/10.34062/afs.v10i2.13983

ABSTRACT: *Mimosa caesalpiniifolia* is a native species from Northeast Brazil, with good soil and climate adaptation, fast growth and potential for multiple use. Because of these characteristics, it has been considered a promising species for forestry. This work aimed to evaluate the growth and productivity of *Mimosa caesalpiniifolia* at 75 months of age, in a homogeneous plantation located in the state of Rio Grande do Norte, Northeastern Brazil. The data were collected in a 0.05 ha plot with 84 individuals, submitted to thinning at 12 and 55 months. The variables height (H), diameter at breast height (DBH), and diameter at base (DAB) were evaluated. The productivity of the plantation was estimated in terms of total volume (m^3) and stacked volume (st), number of stems and mean annual increment (MAI). On average, the individuals were 4.85 m tall, 12.05 cm in diameter at the base (DAB) and 8.42 cm DBH. Each individual presented an average of 6.07 stems. The estimated productivity was 43.88 m^3 ha^{-1}, with MAI of 7.02 m^3 ha^{-1} $year^{-1}$, and the estimated stacked wood volume was 111.89 st ha^{-1}. The results showed the high potential of the species for the production of stakes and fence posts, as well as for the production of kindling and firewood, aiming at the use of all the biomass produced. Therefore, the planting of this species for the production of wood serves as an alternative to meet demands in the Northeast of Brazil.

Mimosa caesalpiniifolia Benth. como alternativa para produção de madeira no Nordeste do Brasil

RESUMO: *Mimosa caesalpiniifolia* é uma espécie nativa do Nordeste do Brasil, com boa adaptação edafoclimática, crescimento rápido e potencial de uso múltiplo. Por causa dessas características, tem sido considerada uma espécie promissora para a silvicultura. Este trabalho teve como objetivo avaliar o crescimento e produtividade de *Mimosa caesalpiniifolia* aos 75 meses de idade, em plantio homogêneo localizado no estado do Rio Grande do Norte, Nordeste do Brasil. Os dados foram coletados em um talhão de 0.05 ha com 84 indivíduos, submetidos ao raleio aos 12 e 55 meses. Foram avaliadas as variáveis altura, diâmetro a altura do peito (DAP) e diâmetro na base da árvore (DNB). A produtividade do plantio foi estimada em termos de volume total e volume empilhado, número de fustes e incremento médio anual (IMA). Em média, os indivíduos apresentaram 4,85 m de altura, 12,05 cm de diâmetro na base (DAB) e 8,42 cm de DAP. Cada indivíduo apresentou em média 6,07 fustes. A produtividade estimada foi de 43,88 m^3 ha^{-1}, com IMA de 7,02 m^3 ha^{-1} ano^{-1}, e o volume de madeira empilhada estimado foi de 111,89 st ha^{-1}. Os resultados demonstraram elevado potencial da espécie para produção de estacas e mourões, bem como para a produção de estacotes e lenha, visando o aproveitamento de toda a biomassa produzida. Portanto, o plantio dessa espécie para a produção de madeira serve como alternativa para atender demandas no Nordeste do Brasil.

Introduction

The Caatinga, the main biome of the Northeast region of Brazil, is subject to long periods of drought. It occupies about 10% of the country's territory, distributed in the states of Rio Grande do Norte, Paraíba, Ceará, Pernambuco, Piauí, Alagoas, Sergipe, Bahia and northern Minas Gerais (Silva et al. 2017; MMA 2022). An estimated 27 million people live in this region, with a large portion living in unfavorable socioeconomic conditions, which makes the biome one of the main sources of sustenance for the population (MMA 2022).

Although the Caatinga is of great importance for the conservation of biodiversity, due to the high number of endemic species, it is subject to rapid illegal deforestation in the past few years (Pereira Júnior et al. 2014; Althoff et al. 2018). The vegetation of the biome is a major source of energy in much of the Northeast region. It is estimated that 254 thousand tons of charcoal and 1.7 million m^3 of firewood produced in the northeast region come from plant extraction (IBGE 2021). The increasing energy needs of a region that suffers from lack of investment and presence of the government (Gioda 2019) is a factor intensifying the deforestation of the biome.

The red ceramic sector is the main firewood-consuming productive segment in the region and is responsible for the estimated consumption of 50% of the firewood produced, used for heating kilns (Henriques Junior and Rodrigues 2017). The states of Bahia, Piauí, Pernambuco and Sergipe stand out as the largest producers of firewood for cooking (IBGE 2021).

Therefore, seeking alternatives to meet the demand for firewood in the Northeast, it is important to encourage the establishment of commercial forest stands planted with forest species native to the biome, which have natural adaptations to the soil and climate conditions. In this sense, *Mimosa caesalpiniifolia* Benth. is one of the main woody plants that make up the native Caatinga vegetation. It is an arboreal species belonging to the Fabaceae family, popularly known as 'sabiá', and has been considered promising for forestry. The species occurs naturally in the states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba and Pernambuco, where annual rainfall varies from 600 to 1,000 mm, while it is less present in drier areas (Maia 2004).

As it is a leguminous species that has the characteristic of fixing nitrogen through symbiotic association with bacteria (Souza et al. 2022), promotes the incorporation of nitrogen in the soil. This aspect makes the species suitable for recovery of degraded areas (Oliveira et al. 2018). Besides this use, the species can also be planted for production of wood and fodder for livestock (Rodrigues et al. 2020). It also has pharmacological and medicinal properties (Silva et al. 2020; Ucella-Filho et al., 2022), in addition to being a potential producer of condensed tannins, which can generate a complementary and sustainable income for rural producers (Azevêdo et al. 2017; Pereira et al. 2018). Its wood has a specific weight of around 0.87 g/cm^3 and a fixed carbon content of approximately 73%, characteristics that qualify it as an option for firewood and charcoal production (Ribaski et al. 2003; Batista et al. 2020).

Thus, due to the multiple use capacity of the species, this work aimed to evaluate the growth and productivity of *Mimosa caesalpiniifolia* at 75 months of age, in a homogeneous plantation located in the state of Rio Grande do Norte, Northeastern Brazil.

Material and Methods

Study area

The study was carried out in a homogeneous *Mimosa caesalpiniifolia* plantation, with 3 m x 3 m spacing, located in the municipality of Macaíba, state of Rio Grande do Norte (Figure 1). The local climate, according to the Köppen classification, is type As, with a concentrated rainy season between May and July, while the dry season occurs between September and December. The average annual rainfall is approximately 1,280 mm and the monthly temperature varies between 24 and 28°C (Alvares et al. 2013). According to the Brazilian Soil Classification System, the predominant soil is classified as Quartz Neosol, characterized by low natural fertility and sandy texture (Mascarenhas et al. 2005; Santos et al. 2018).

Implantation and silvicultural treatments

In the preparation of the soil for planting, cross tilling was carried out to systematize the area. A total of 396 *Mimosa caesalpiniifolia* seedlings were planted, forming 3,564 m^2 of effective planted area. The seedlings were produced from seeds obtained from plants of a commercial plantation in Macaíba, Rio Grande do Norte, which were sown in polyethylene bags with capacity for 1.5 kg of substrate, filled with sand + organic compost in a 1:1 ratio. Subsequently, the bags were placed in a greenhouse. The seedlings were irrigated daily to supply the water demand necessary for growth and development. They were transplanted when they were 60 cm high on average. Before planting, the leaf-cutting ants were fought with the use of granulated ant bait.

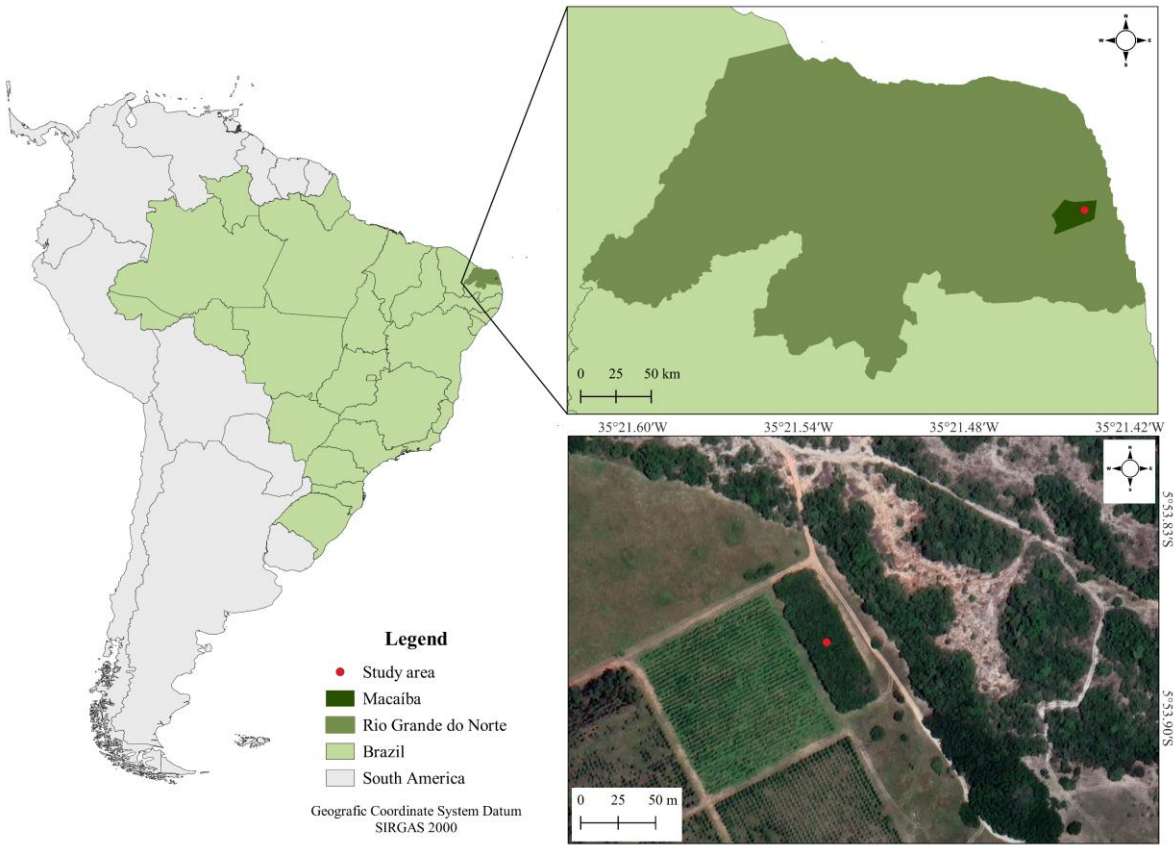

Figure 1. Location of the homogeneous plantation of *Mimosa caesalpiniifolia*, Macaíba, Rio Grande do Norte Brazil.

Data collection

The data were collected 75 months after planting and a plot of 0.05 ha containing 84 individuals was sampled. In this plot, all individuals were submitted to thinning, which consisted of cutting the excess stems to prioritize the main stems. Thinning was carried out at 12 and 55 months after planting, manually with the help of saws.

The data collection included measurement of the total height (H), with a centimeter measuring stick; the circumference at breast height (1.30 m from the ground (CBH) and circumference at the base of the tree (CAB), a tape measure in centimeters. The CBH and CAB values were converted into diameters (DBH and DAB). Subsequently, the equivalent diameter of the sampled individuals with more than one trunk was calculated using the equation:

$$\mathrm{Deq} = \sqrt{\sum_{i=1}^{n} \mathrm{DBH}^2} \qquad (1)$$

Data analysis

The equivalent diameter and total height were used to estimate the individual volume and the total volume of the plot and then the volume per hectare was estimated. The estimate of the stacked volume, in steres (st ha^{-1}), was calculated using the stacking factor of 2.55 proposed by Barros et al. (2010) for *Mimosa caesalpiniifolia*. The average annual increment (IMA), which expresses the average annual growth of the plantation, was determined by the quotient between the plant volume (m^3 ha^{-1}) and age.

The distribution of the number of individuals, bundles, and volume by diameter class was determined for all individuals sampled. The number and range of classes were defined using the method proposed by Sturges. First, the number of classes was calculated using the equation:

$$k = 1 + 3{,}322 \times (log 10^n) \qquad (2)$$

Where:
k = number of classes;
n = number of individuals observed.

Then, the class interval was calculated, which was obtained through the ratio between the total amplitude and the number of classes:

$$w = \frac{k}{R} \qquad (3)$$

Where:
w = class interval;
R = amplitude - difference between the highest and lowest value observed in the sample;
k = number of classes.

The data obtained were tabulated in Microsoft Excel and statistically analyzed in software R version 4. 2.1 (R Core Team 2022).

Results and Discussion

The mean values obtained for the dendrometric variables of *Mimosa caesalpiniifolia* at 75 months of age in homogeneous planting are shown in Table 1. On average, the individuals presented 4.85 m in height, 12.05 cm in diameter at base (DAB), and 8.42 cm of DBH. Each individual presented, on average, 6.07 stems.

Table 1. Descriptive statistics of height (H), DAB (cm), DBH (cm), number of stems, and volume (m^3) of *Mimosa caesalpiniifolia* at 75 months of age.

Variables	Minimum	Maximum	Mean ± SD	VC
H	3.50	6.00	4.85 ± 0.60	11.17
DAB	5.98	23.04	12.05 ± 0.38	27.84
DBH	4.55	14.54	8.42 ± 0.23	24.29
N° of stems	3.00	11.00	6.07 ± 0.21	30.05

VC = coefficient of variation

According to Ribaski et al. (2003), in plantations using 3 m x 3 m spacing, at 85 months of age, *Mimosa caesalpiniifolia* had an average height of 6 m, with an average annual increase of 1 m, and 6.5 cm of DBH. Although we found a lower average height, the maximum height was similar to that mentioned by the other authors, demonstrating the investment in height growth of some trees in our plantation. However, the average DBH obtained in this study was significantly greater, which indicates greater investment by most trees in growth of diameter instead of height, probably the result of the thinning carried out.

In a semiarid region of Ceará, Carvalho et al. (2004), evaluating the production of wood and forage in a silvopastoral system from thinning of *Mimosa caesalpiniifolia*, observed that after 84 months the average height varied between 6.2 and 7.2 m, while the average DBH varied between 4.5 and 6.8 cm. The authors pointed out that the greater the number of stems kept in the plant, the smaller its growth in height and diameter. This demonstrates the importance of thinning to promote greater growth of the species in a shorter period of time, because with sprouting control, competition between stems is reduced. The height results found by these authors were higher than those obtained in this study, but the diameters were smaller, possibly due to greater water availability in the region where our study was carried out.

Barros et al. (2010), evaluating the growth of native and exotic species in the municipality of Araripe, Penambuco, with planting spacing of 3 m x 2 m, observed that at 77 months of age, *Mimosa caesalpiniifolia* was the species with the greatest growth in height, averaging 8.11 m, ranging from 7.10 to 9.25 m. The authors found a mean DBH of 4.08 cm, lower than the average obtained in this study.

Studies to quantify the growth and productivity of *Mimosa caesalpiniifolia* are scarce. It is observed that the average height and DBH values obtained in this study differed from the results found by Ribaski et al. (2003), Carvalho et al. (2004) and Barros et al. (2010). This indicates that under different silvicultural treatments and edaphoclimatic conditions the species presents a different behavior in terms of growth, being able to have greater investment in growth in height than in diameter or reciprocally. Therefore, the quality of the site directly influences the growth in height and DBH of the species.

The estimated number of stems for *Mimosa caesalpiniifolia* at 75 months of age, even though it had undergone two prunings, was 9,286 per hectare. The production considering 96-month-old plantations can vary between 4,000 and 9,000 stems ha^{-1} (Ribaski et al. 2003), which demonstrates the high production capacity of stems per hectare by the species.

The estimated volumetric productivity was 43.88 m^3 ha^{-1}, with an MAI of 7.02 m^3 ha^{-1} $year^{-1}$. The estimated stacked wood volume was 111.89 st ha^{-1}. Barros et al. (2010), in a *Mimosa caesalpiniifolia* plantation at 77 months of age located in the Araripe, Pernambuco, found greater results than ours, with estimated volumetric productivity of 52.28 m^3 ha^{-1} and MAI of 8.04 m^3 ha^{-1} $year^{-1}$. This difference in productivity may be related to the thinning performed at 12 and 55 months after planting.

According to Ribaski et al. (2003), *Mimosa caesalpiniifolia* wood production varies according to the ecological zone in which the species is planted. The authors reported that in a sub-humid region, in 72-month-old plantations, using 2 m x 2 m spacing, the average volume obtained was 46.50 m^3 ha^{-1}, with MAI of approximately 7.70 m^3 ha^{-1} $year^{-1}$, while in a region with a hot semiarid climate, in more widely spaced plantations (3 m x 2 m), production was lower, with MAI around 5 m^3 ha^{-1} $year^{-1}$.

The results obtained for the production of solid wood were similar to those described by Ribaski et al. (2003) in the sub-humid region.

However, the difference in spacing can lead to variations in the number of stems per hectare as well as growth in diameter. In denser spacings, trees tend to have fewer stems and less growth in diameter, due to greater competition for water and nutrients, as plant has a smaller unit of area. In addition, at these spacings, there is greater growth in height due to greater competition for sunlight. These factors directly influence wood production. Therefore, the spacing must be determined based on the final product that will be marketed.

From the data obtained, the distribution of the number of individuals, number of stems, and the volume of solid wood per hectare in diameter classes was performed (Figure 2). The diametric distribution showed a tendency towards normality, which is expected for planted forests due to the uniformity of planting.

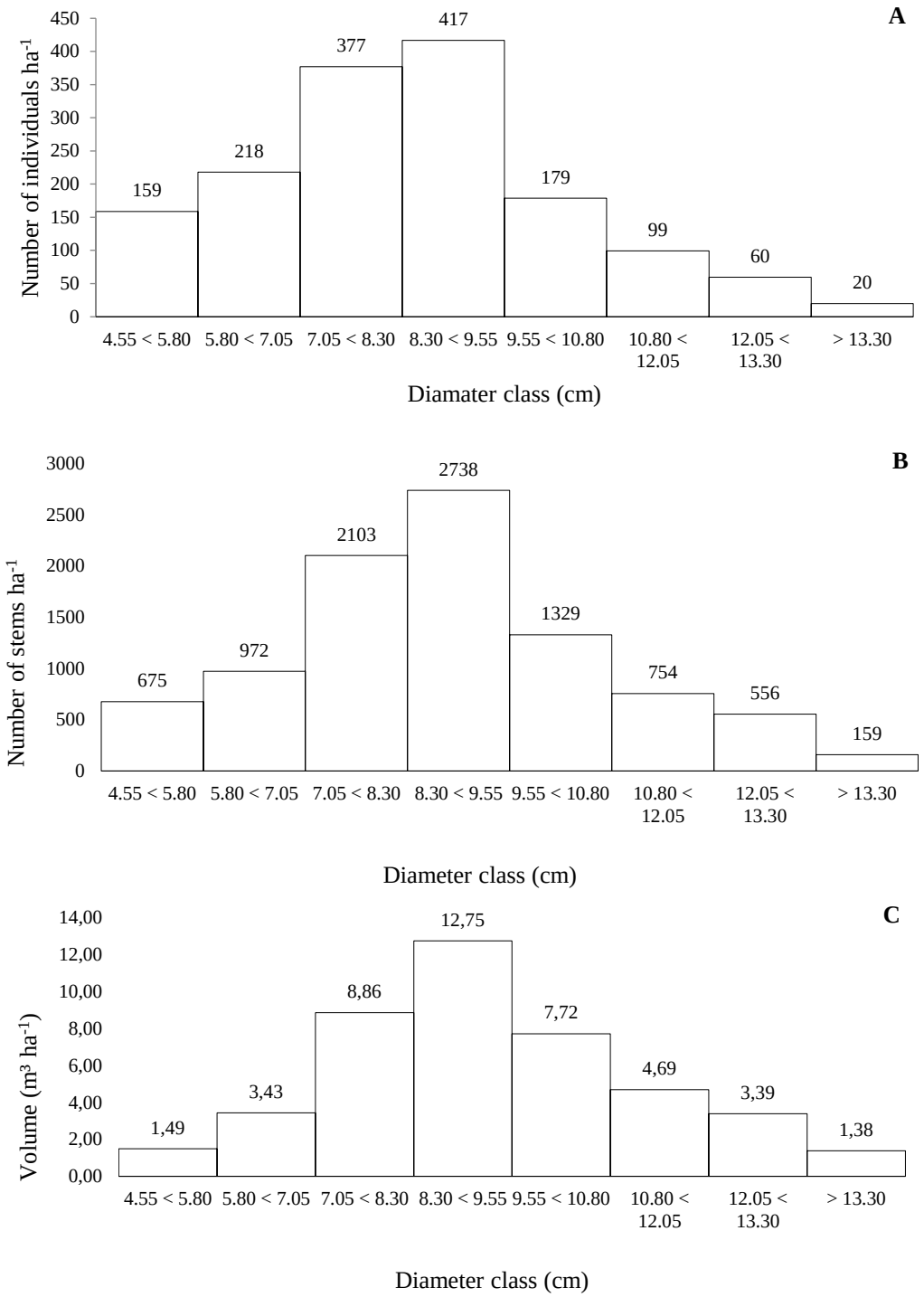

Figure 2. Distribution in diameter classes of the number of individuals (A), number of stems (B) and estimated solid wood volume per hectare (C) of *Mimosa caesalpiniifolia* at 75 months of age.

The largest number of individuals was observed in classes ranging from 7.05 and 8.30 cm and 8.30 to 9.55 cm, with 377 and 417 individuals per hectare, respectively (Figure 2A). When evaluating the distribution in diameter classes of the number of stems and volume of solid wood per hectare, like for the number of individuals, the highest estimated values were found in classes ranging between 7.05 and 8.30 cm and 8.30 and 9.55 cm (Figure 2). In the class ranging from 7.05 to 8.30 cm, 2,103 stems ha^{-1} were estimated, while in the class ranging from 8.30 to 9.55 cm, 2,738 stems ha^{-1} were estimated (Figure 2B). Regarding the distribution of estimated solid wood volume per hectare in diameter classes, 8.86 and 12.75 m^3 of wood were observed in classes between 7.05 and 8.30 cm and 8.30 and 9.55 cm, respectively (Figure 2C).

Considering the classification proposed by Carvalho et al. (2004), for the production of stakes (diameter > 7.0 cm and length of 2.2 m), kindling (diameter between 5.0 and 6.9 cm and length of 1.1 m) and firewood (diameter between 3 .0 and 4.9 cm and a length of 1.0 m), it can be seen that based on the data on height variation obtained (Table 1), the wood produced by *Mimosa caesalpiniifolia* at 75 months of age is suitable for the production of stakes, kindling and firewood.

However, when considering the variation in DBH data and the distribution of the number of stems ha^{-1} in diameter classes, 17.74% of the total stems would be suitable for use as kindling and firewood, while the rest, i.e., 82.26%, could be used as stakes. Besides the production of stakes, according to Francelino et al. (2003), when the stems of the species are between 7 and 14 cm in diameter, they can also be used for the production of fence posts.

Carvalho et al. (2004), Ribaski et al. (2003), and Barros et al. (2010) found mean height values higher than those observed in this study for *Mimosa caesalpiniifolia* at similar ages. However, the increase in solid wood productivity is directly related to the investment of plants in diameter growth. Regression analysis showed that trees with larger diameter stems were those with the highest production of solid wood. The relationship between the volume produced and the DBH indicates that the greater the DBH of the tree, the greater the production of wood (Figure 3B).

This pattern was also observed by Azevêdo et al. (2014), studying the volume and mass ratio of *Mimosa tenuiflora* (Willd.) Poir.) wood as a function of the plants' phonological. They found that in the period when the species had the largest volume of wood was when trees with the largest diameter of the trunk were collected, showing that these variables are strongly related. Alves Junior (2010), studying various species of Caatinga plants in the municipality of Floresta, Pernambuco, also found a strong correlation between volume and DBH (0.835541), confirming the existence of this relationship in several Caatinga species.

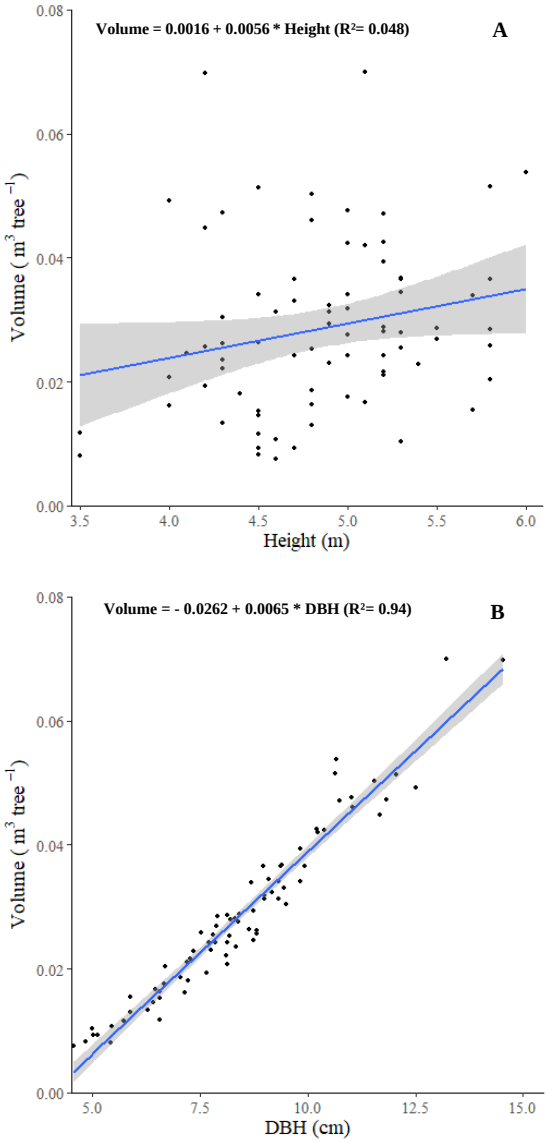

Figure 3. Dispersion of the volume obtained for *Mimosa caesalpiniifolia* at 75 months of age according to height (A) and DBH (B).

Therefore, according to Moura et al. (2006), when rationally managed, a *Mimosa caesalpiniifolia* stand can produce an average of 66 t ha^{-1} of total biomass, which can be used as firewood, charcoal, kindling, and fence posts. Because it is a species that presents many stems and a high capacity for re-growth, the increase in the productivity of the plantation can be obtained through the implementation of silvicultural practices, such as the technique of thinning to diminish the competition between the plants for sunlight, water and nutrients.

Conclusions

Mimosa caesalpiniifolia at 75 months of age presented volumetric productivity of 43.88 m^3 ha-1

and piled wood volume of 111.89 st ha^{-1}. These results indicate a high potential of the species for the production of stakes and fence posts, since most of the stems had a diameter above 7 cm, as well as for the production of kindling and firewood, aiming at the use of all the biomass produced, since some stems had small diameters. Therefore, the planting of this species for the production of wood serves as an alternative to meet demands in the Northeast of Brazil.

References

Alvares CA, Stape JL, Sentelhas PC, Gonçales JLM, Sparovek G (2013) Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22(6):711-728. doi: 10.1127/0941-2948/2013/0507

Althoff TD, Menezes RSC, Pinto AS, Pareyn FGC, Carvalho AL, Martins JCR, Carvalho EX, Silva ASA, Dutra ED, Sampaio EVSB (2018) Adaptation of the century model to simulate C and N dynamics of Caatinga dry forest before and after deforestation. *Agriculture, Ecosystems & Environmen*t, 254:26-34. doi: 10.1016/j.agee.2017.11.016

Alves Junior FT (2010) Estrutura, biomassa e volumetria de uma área de caatinga, Floresta-PE. Tese, Departamento de Ciência Florestal, Universidade Federal Rural de Pernambuco. 151p.

Azevêdo TKB, Paes JB, Calegari L, Nascimento JWB (2014) Relações entre volume e massa da madeira e casca de jurema-preta (*Mimosa tenuiflora*). *Revista Brasileira de Ciências Agrárias – Brazilian Journal of Agricultural Sciences*, 9(1):97-102. doi: 10.5039/agraria.v9i1a3066

Azevêdo TKB, Cardoso MGA, Campos DBP, Souza DG, Nunes LJ, Gomes JPS, Carnaval AAA, Silva GGC (2017) Substâncias tânicas presentes em partes da árvore Sabiá (*Mimosa Caesalpiniifolia* Benth.) em plantio comercial de 5 anos. *Revista Agroecossistemas*, 9(2)263-274. doi: 10.18542/ragros.v9i2.5033

Barros BC, Silva JAA, Ferreira RLC, Rebouças ACMN (2010) Volumetria e sobrevivência de espécies nativas e exóticas no polo gesseiro do Araripe, PE. *Ciência Florestal*, 20(4):641-647. doi: 10.5902/198050982422

Batista FG, Melo RR, Medeiros DT, Oliveira AGS, Freitas CBA, Silva EDG, Pimenta AS (2020) Longitudinal variation of wood quality in the five forest species from Caatinga. *Revista Brasileira de Ciências Agrárias – Brazilian Journal of Agricultural Sciences*, 15(4):1-9. doi: 10.5039/agraria.v15i4a8572

Carvalho FC, Garcia R, Araujo Filho JA, Couto L, Neves JCL, Rogério MCP (2004) Manejo *in situ* do sabiá (*Mimosa caesalpiniifolia* Benth.) para produção simultânea de madeira e forragem, em sistema silvipastoril. *Agrossilvicultura*, 1(2):121-129.

Francelino MR, Fernandes Filho EI, Resende M, Leite HG (2003) Contribuição da Caatinga na sustentabilidade de projetos de assentamentos no sertão norte-rio-grandense. *Revista Árvore*, 27(1): 79-86. doi: 10.1590/S0100-67622003000100011

Gioda A (2019) Características e procedência da lenha usada na cocção no Brasil. *Estudos avançados*, 33(95):133-149. doi: 10.1590/s0103-4014.2019.3395.0009

Souza HA, Pompeu RCFF, Tonucci RG, Fernandes FÉP, Primo AA, Ferreira ACM, Leite LFC (2022) Phosphate fertilization in 'sabiá' (*Mimosa caesalpiniifolia* Benth.) implantation in crop-forest system in semiarid region. *Revista Brasileira de Ciências Agrárias*, 17(2):1-7. doi: 10.5039/agraria.v17i2a135.

Henriques Junior MF, Rodrigues JAP (2020) Cerâmica Vermelha: projeto EELA no brasil. Instituto Nacional de Tecnologia. Availableat:<http://www.int.gov.br/noticias/livro-cer%C3%A2mica-vermelha-%E2%80%93-projeto-eela-no-brasil-baixe-aqui>. Consulted on: May 27, 2020.

IBGE - Instituto Brasileiro de Geografia e Estatística (2021) - Produção da extração vegetal e da silvicultura (PEVS). Available at:< https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=774>. Consultedon: October 27, 2022.

Mascarenhas JC, Rocha DEGA, Mascarenhas JC, Souza Junior LC, Pires STM, Carvalho VGD (2005) Projeto cadastro de fontes de abastecimento por água subterrânea. Diagnóstico do município de Macaíba, estado do Rio Grande do Norte. Available at:<http://rigeo.cprm.gov.br/xmlui/handle/doc/17018>. Consulted on: May 5, 2020.

Maia GN (2004) *Caatinga:* árvores e arbustos e suas utilidades. 1. ed. São Paulo: D & Z Computação Gráfica e Editora. 413p.

MMA - Ministério do Meio Ambiente. Biomas Brasileiros. *Caatinga.* Availableat:< https://www.gov.br/mma/pt-br/assuntos/ecossistemas-1/biomas/caatinga >. Consulted on: October 27, 2022.

Moura ON, Passos MAA, Ferreira RLC, Molica SG, Lira Junior MA, Lira MA, Santos MVF (2006) Distribuição de biomassa e nutrientes na área de *Mimosa caesalpiniiaefolia* Benth. *Revista Árvore*, 30(6):877-884. doi: 10.1590/s0100-67622006000600002

Oliveira FRA, Souza H, Carvalho MAR (2018) Green fertilization with residues of leguminous trees for cultivating maize in degraded soil. *Revista Caatinga*, 31(4):798-807. doi: 10.1590/1983-21252018v31n401rc

Pereira Júnior LR, Andrade AP, Araújo KD, Barbosa AS, Barbosa FM (2014) Espécies da Caatinga como alternativa para o desenvolvimento de novos fitofármacos. *Floresta e Ambiente*, 21(4):509-520. doi: 10.1590/2179-8087.024212

Pereira TP, Modesto EC, Nepomuceno DD, Oliveira OF, Freitas RSX, Muir JP, Dubeux Junior JCB, Almeida JCC (2018) Characterization and biological activity of condensed tannins from tropical forage legumes. *Pesquisa Agropecuária Brasileira*, 53(9):1070-1077. doi: 10.1590/s0100-204x2018000900011

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available in:< https://www.R-project.org/>.

Ribaski J, Lima PCF, Oliveira VR, Drumond MA (2003) Sabiá (*Mimosa caesalpiniifolia*): árvore de múltiplo uso no Brasil. Colombo: Embrapa Florestas. Available at:<https://www.embrapa.br/busca-de-publicacoes/-/publicacao/309651/sabia-mimosa-caesalpiniaefolia-arvore-de-multiplo-uso-no-brasil>. Consulted on: June 9, 2020.

Rodrigues ABM, Giuliatti NM, Pereira Júnior A (2020) Aplicação de metodologias de recuperação de áreas degradadas nos biomas brasileiros. *Brazilian Applied Science Review*, 4(1):333-369. doi: 10.34115/basrv4n1-021

Santos HG, Jacomine PKT, Anjos LHC, Oliveira VA, Lumbreras JF, Coelho MR, Almeida JA, Araujo Filho JC, Oliveira JB, Cunha TJF (2018) Sistema Brasileiro de Classificação de Solos. Embrapa Solos. Available at:<http://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1094003>. Consulted on: June 17, 2020.

Silva JMC, Barbosa LCF, Leal IR, Tabarelli M (2017) The Caatinga: understanding the challenges. In: Silva JMC, Leal IR, Tabarelli M (ed) *Caatinga:* the largest Tropical Dry Forest region in South America. Springer International Publishing. p. 3-19. doi: 10.1007/978-3-319-68339-3

Silva JN, Monção NBN, Farias RRS, Citó AMG, Chaves MH, Araújo MRS, Lima DJB, Pessoa C, Lima A, Araújo ECC, Militão GCG, Costa MP, Capasso R, Ferreira PMP (2020) Toxicological, chemopreventive, and cytotoxic potentialities of rare vegetal species and supporting findings for the Brazilian Unified Health System (SUS). *Journal of Toxicology and Environmental Health*, 83(13-14):525-545. doi: 10.1080/15287394.2020.1780658

Ucella Filho JGM, Lorenço MS, Souza EC, Costa GM, Piccolo RH, Dias Junior AF, Mori FA (2022) Tannin-rich tree bark extracts inhibit the development of bacteria associated with bovine mastitis. *BioResources*, 17(4):6578-6587. doi: 10.15376/biores.17.4.6578-6587